DETERMINATION OF PHYSICAL AND MECHANICAL PROPERTIES OF POLYPROPYLENE FIBRE CONCRETE

Hakan SARIKAYA, Gülşah SUSURLUK

Faculty of Engineering, Civil Engineering Department, Usak University, Usak, Turkey

Associate's Degree Vocational School, Textile Technology Department, Beykent University, Istanbul, Turkey

hakan.sarikaya@usak.edu.tr
gulsahsusurluk@beykent.edu.tr

Abstract: In this study, it is aimed to investigate the physical and mechanical properties of concretes obtained by using polypropylene fibers at different ratios by keeping amount of cement constant in the concrete mixtures. According to experimental results, it was seen that the increasing fiber dosage in the concrete mixtures, flexural strength and ultrasonic velocity was increased by addition of fibers to concrete, compressive strength and slump was decreased.

Keywords: fiber concrete**,** polypropylene fiber, mechanical strengths.

Introduction

Since the existence of humankind the second basic necessity has been the sheltering after the necessity of eating and drinking, In this way the building sector has always remained on the agenda and has continued to work on developing practical methods. In today's world, as in all areas, the basic goal is to reach the solution at the earliest with minimal expenditure. Various special properties have been developed or some special concrete with different production and application techniques are widely used due to emerging needs in today's use. It is very important to design and economical production of concrete for the purpose of use. (Sarıkaya, 2014). Due to the increase in the world population, complex and multi-storey buildings have been widespread in recent years instead of simple and single storey buildings. As the building height and number of floors increase, the quality of the material used becomes important (Erdem vd., 1997). In multi-storey buildings, concrete performance is of great importance in order to reduce the structural security and the effect of the earthquake (Neville, 1981).

Concrete; is a composite material consisting of mortar phase and aggregate which is obtained by mixing cement, water, aggregate and additives if necessary (mineral, chemical, fiber etc.) in certain conditions and ratios and which is in plastic form at the beginning and gains resistance by hardening by developing chemical reaction (hydration) over time between cement and water (Özel, 2007). When concrete has just been mixed, it takes the name of fresh concrete and when it hardens it becomes hardened concrete (Neville, 1993). In concrete, when the materials entering the composition are specifically rated, the mixture can be poured anyplace and brings a plastic mass that can take the shape of the mold and the size (Baradan, 1997).

Cement based materials such as concrete, tensile strength and tensile unit deformation capacity are materials with very low brittle construction. Conventional concrete is typically; it shows poor performance in terms of fatigue strength, cavitation and abrasion resistance, tensile strength, deformation capacity, shear strength, load carrying strength after cracking and toughness. Where these properties of concrete are obviously required, the addition of high-tech fibers produced from different materials within the concrete improves the above weaknesses of the concrete, thereby increasing the interest in materials such as concrete. The result of the addition of technical properties high fiber, produced from different materials in concrete, improves the poor features of the concrete above, causing to increase the interest in materials such as concrete. Thus, polypropylene fiber, carbon fiber, plastic-glass based fibers and steel fibers have begun to be used in concrete. In terms of advantages in the field of Civil Engineering, the importance of fiber reinforced concrete is increasing rapidly and important steps have been taken to improve the properties of composites (Yardımcı, 2007).

The polypropylene fiber used in this study is a very light polymer that is contained within the thermoplastics as material. It forms almost half of the raw materials used in daily life. From this point of view, it is also possible to say that production is a cheap plastic. The most important effect of polypropylene fiber concrete in concrete or plaster is to check cracks due to plastic shrinkage within the first few hours after pouring concrete into the mold. In the first phase of concrete hardening, the velocity of formation of concrete strength is slower than the rate of formation of tensile stresses due to shrinkage. This plastic shrinkage is essentially a natural consequence of chemical reaction and evaporation starting between water and cement (Arazsu, 2012). Polypropylene fibers increase the mechanical strength of concrete compared to steel fibers and are not very effective. Yet, at a minimum, they give to concrete energy absorbing capability the plastic shrinkage with the feature is also very effective. Especially polypropylene fibers are preferred against very strong shrinkage. The function of polypropylene fibers, while the concrete is limited to soft, plastic phase, the strength-increasing effect of steel fibers, after taking the concrete setting and hardening it will continue to be noticeable. In the plastic phase of the concrete there is a preventive and limiting effect of the cracks of steel fibers. However, it is weaker than the effect of polypropylene fibers dispersed perfectly in concrete (Figure 1). However, with the reduction of cracks due to long-term drying shrinkage of hardened concrete, steel fibers significantly increase the strength of the concrete by giving a certain durability and toughness to the material (Bekaert, 1998).

Figure 1. Polypropylene Fiber

Material and Methods

In this study, 15 cement samples were produced at 10 cm x 10 cm x 10 cm sizes using 1%, 2% and 3% (polypropylene fiber) of cement weight, keeping amount of cement constant for C 30 concrete**.** The chemical properties of cement, normal aggregate and polypropylene fiber used are shown in Table 1 and the chemical and physical properties of the polypropylene fiber are shown in Table 2.

Table 1. Chemical Properties of Cement, Aggregate and Polypropylene Fiber Used in Concrete Mixtures

Composition	CEM I 42,5 R (%)	Normal Aggregate (%)	Polypropylene Fiber (%)
SiO_2	20.02	2.75	0.38
Fe_2O_3	3.52	1.29	0.06
Al_2O_3	5.16	-	-
CaO	63.46	0.2	53.85
MgO	1.03	2.8	0.34
SO_3	2.74	-	-
Loss of ignition	2.35	-	-

Table 2. Chemical and Physical Properties of Polypropylene Fibre

Appearance	Natural White Fibers
Purity	% 100 Pure
Specific Gravity	0.91 g/cm^3
Module of Elasticity	3000-3500 N/mm^2 (MPa)
Tensile Strength	450/700 N/mm^2 (MPa)
Melting Point	162 ˚C
Ignition Point	593 ˚C
Length	6mm - 12 mm – 19 mm
Profile &Diameter	Circular 18µm - 40 µm

Production of concrete samples, physical and mechanical properties tests were carried out in the Construction Laboratory of Civil Engineering Department of Uşak University. In this study, concrete was produced in 4 different mixing ratios. The amount of cement and fiber dosage was kept constant in all mixtures. Mixing ratios of the produced samples are shown in Table 3. Natural spring water was used for mixing water. The concrete mixing process was carried out with the help of a vertical axis mixer. In order to determine the consistency of the samples, slump with abrams cone concrete temperatures and spesific bulk densitys were measured. For use in various experiments, the mortar was placed in three stages, 100 mm × 100 mm × 100 mm size cube molds on vibratory table unit. At each stage, the mortar was vibration by the vibratory table tool for 10 seconds. For each series, 15 cube samples were produced. The samples were left in mold for 24 hours. At the end of this period, the samples were removed from the mold with the aid of rubber wedges. The samples were kept in the curing pool until the day of the experiment.

Table 3. Mixture ratios of the produced samples

Mix	Cement (% wt)	Polypropylene Fiber (%)
NB	100	-
NL1	99	1
NL2	98	2
NL3	97	3

ASTM C143 (2000) and TS EN 12350-2 (2002) standards have been adopted in many countries. In this experiment also called Abrams Cone; As shown in Figure 2, the top of a 100 mm diameter, 200 mm lower diameter and 300 mm height is cut into three equal layers into a truncated conical metal mold and each layer is freshly squeezed 25 times with a special rod (diameter 16 mm, length 600 mm) concrete filled.

Then the filled concrete was pulled up through the truncated cone mold before it was vibrating. The concrete has collapsed with its own weight and the slump value was measured (Özel 2007).

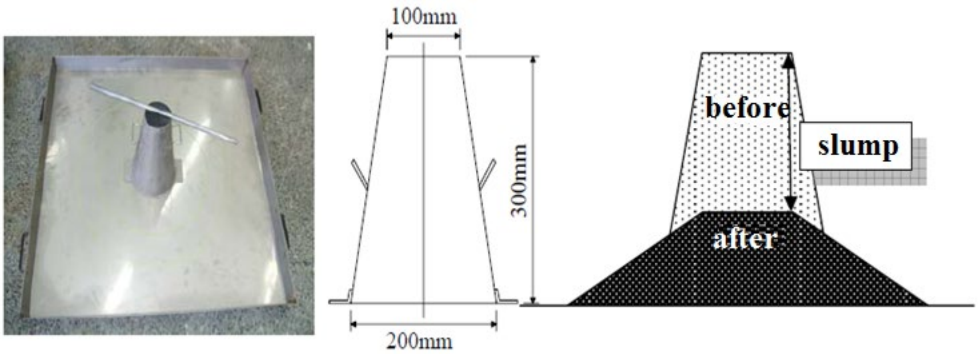

Figure 2. Tools used in the slump test and experimental procedure (Özel, 2007)

In the destructive test method, uniaxial pressure test and flexure test were performed. To measure ultrasonic pulse velocity, ultrasonic measuring instrument in the Construction Laboratory of Civil Engineering Department of Uşak University was used (Fiure 3). The ultrasonic velocity measurement was performed with a 12-volt accumulator-equipped with a digital indicator ultrasonic measuring instrument. The instrument was first set to zero, then calibrated. By spraying grease on both sides of the samples, gaps between the probes and the sample were prevented. By the experiment on the cube samples, the times of passing sound waves were measured.

In evaluating ultrasound velocity test results, the ultrasonic pulse velocity time values (micro second) were calculated in terms of km/s in ultrasonic velocity, calculated by Equation 1.

$$V = \frac{L}{t} \quad (1)$$

V: Ultrasonic velocity (km/s),
L: Sample size (km),
t: Ultrasonic pulse velocity time (s)

Figure 3. Ultrasonic measuring instrument

Results and Discussions

The test results of concrete samples produced within the scope of this study are shown in Table 4. The results of polypropylene fiber added concrete are given in Figure 4-7.

Table 4. Physical and mechanical properties of polypropylene fiber added concrete samples

Mix	Dry Unit Weight (kg/m^3)	Slump (mm)	Ultrasonic Velocity (km/sn)	28 Days Compressive Strength (MPa)	28 Days Flexural Strength (MPa)
NB	2.419	170	19.50	49.76	9.68
NL1	2.395	45	20.10	45.88	9.78
NL2	2.375	30	20.70	45.17	10.15
NL3	2.365	20	21.10	44.19	10.45

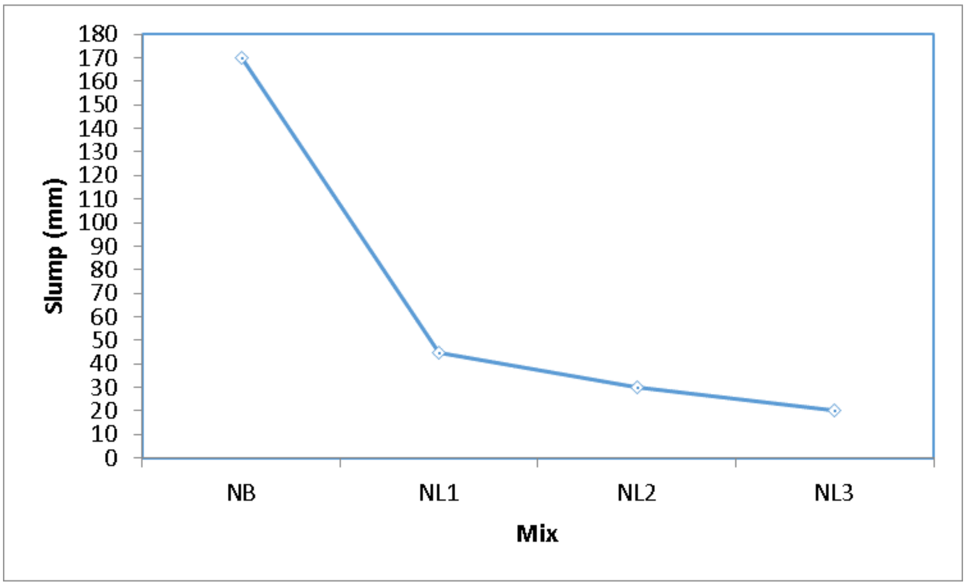

Figure 4. Slump Test Results of Polypropylene Fiber Added Concrete Samples

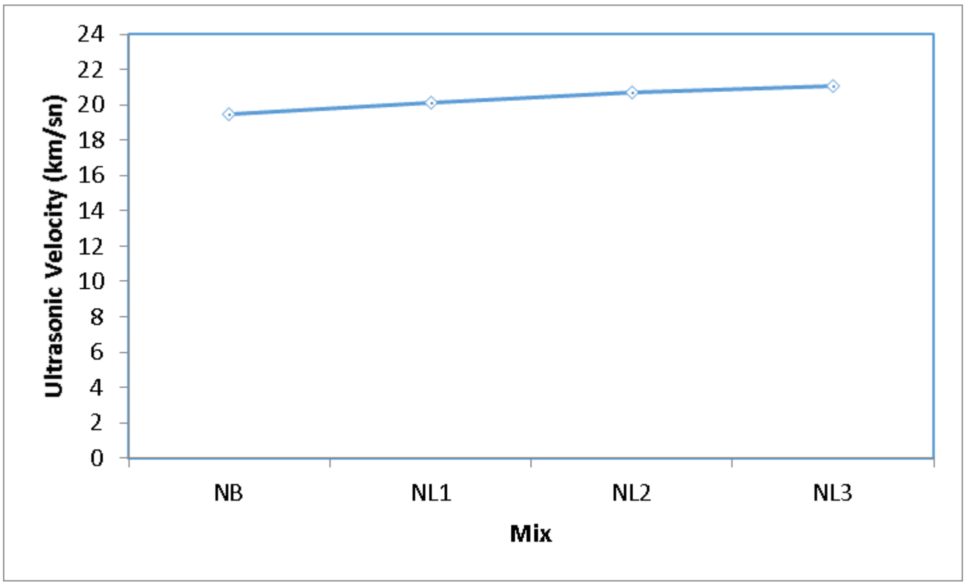

Figure 5. Ultrasonic Velocity Test Results of Polypropylene Fiber Added Concretes Samples

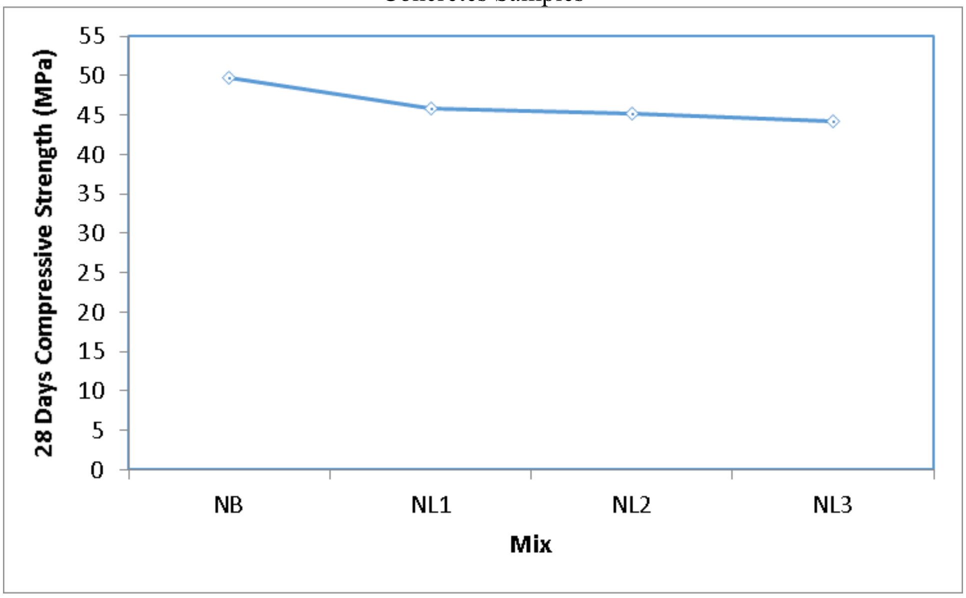

Figure 6. Compressive Strenght Test Results of Polypropylene Fiber Added Concretes Samples

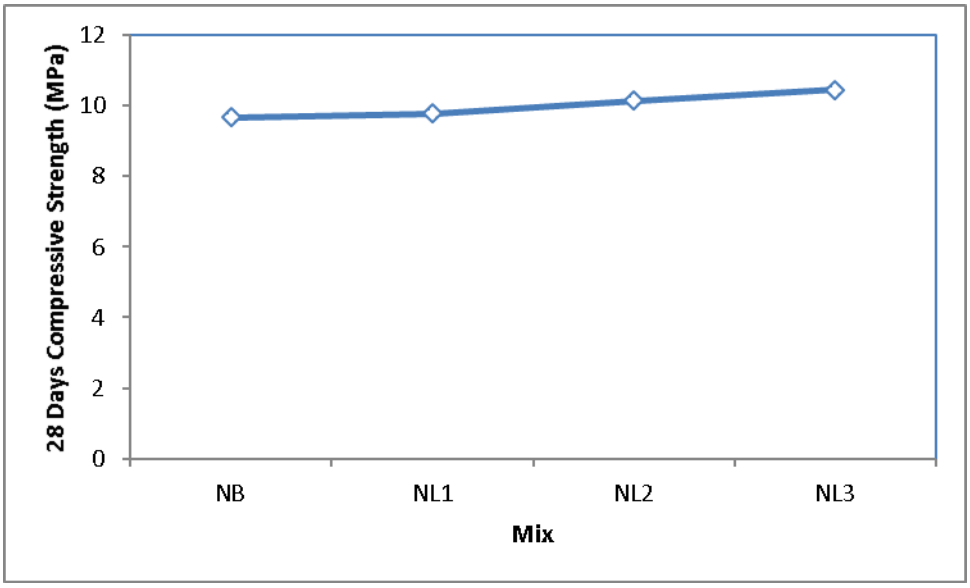

Figure 7. Flexural Strenght Test Results of Polypropylene Fiber Added Concretes Samples

Conclusion

- Increasing fiber dosage in fluid concrete brings about a decrease slump. This is an important feature in terms of cohesion of fresh concrete, even though workability may seem like a negative effect.
- Increasing fiber dosage brings about a decrease in 28 days compresssive strengt results.
- Increasing fiber dosage brings about a increase in 28 days flexural strengt results.
- As the fiber dosage increases, ultrasonic velocity increase.

Reference

Arazsu, U. (2012). Polipropilen Lifli Betonların Taze ve Sertleşmiş Beton Özellikleri. Fırat Üniversitesi Fen Bilimleri Enstitüsü, Yüksek lisans tezi, 63s., Elazığ.

Bekaert, 1998. Duomix Hakkında Genel Bilgiler Kılavuzu. Bekaert, Belgium.

Baradan, B., (1997). Yapı Malzemesi II Dokuz Eylül Üniversitesi Mühendislik Fakültesi Yayınları, İzmir.

Erdem, E., Donat, R., Çetişli, H., 1997. Hydration and Mechanical Properties of Cement Containing Zeolite, 1. International Symposium on Mineral Admixtures in Cement, 6-9 November 1997, 216-220, İstanbul, Türkiye.

Neville, A.M., (1981). Properties of Concrete, Longman Scientific, New York, 843 pp.

Neville, A.M., (1993). Properties of Concrete, ISBN 0-582-23070-5, 3rd edition, London.

Özel, C., (2007). Katkılı Betonların Reolojik Özeliklerinin Taze Beton Deney Yöntemlerine Göre Belirlenmesi, Süleyman Demirel Üniversitesi, Fen Bilimleri Enstitüsü, İnşaat Mühendisliği, Doktora Tezi, Isparta.

Sarıkaya, H., (2014). Bor Katkılı Özellikli Beton Üretimi, Süleyman Demirel Üniversitesi, Fen Bilimleri Enstitüsü, Maden Mühendisliği, Doktora Tezi, Isparta.

TS EN 802, Beton Karışım Hesapları, Türk Standartları Enstitüsü, Ankara.

TS EN 932-1, Beton Agregalarından Numune Alma ve Deney Numunesi Hazırlama Yöntemi, Türk Standartları Enstitüsü, Ankara, Aralık.

TS EN 12350-2 (2002). Beton – Taze Beton Deneyleri – Bölüm 2: Çökme (Slump) Deneyi. Türk Standartları Enstitüsü, Ankara, Turkey.

TS EN 12390-4, 2002. Basınç Mukavemeti Tayini, Türk Standartları Enstitüsü, Ankara, Aralık.

Ünlüer Ö., 2001. Alçı Kalıplar ve Alçı Kalıplarda Mikroyapı Dizaynı, Anadolu Üniversitesi, Fen Bilimleri Enstitüsü, Seramik Mühendisliği Anabilim dalı, Yüksek Lisans Tezi, Eskişehir.

Yardımcı, M.Y. (2007). Çelik Lifli Kendiliğinden Yerleşen Betonların Reolojik, Mekanik, Kırılma Parametrelerinin Araştırılması Ve Optimum Tasarımı. Dokuz Eylül Üniversitesi, Fen Bilimleri Enstitüsü, Doktora Tezi, İzmir.

